P1 1096334

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

November 21, 2003

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: *60/414,300*
FILING DATE: *September 27, 2002*
RELATED PCT APPLICATION NUMBER: *PCT/US03/30646*

By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

M. K. HAWKINS
Certifying Officer

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

09/27/02 J1132 U.S. PTO

09-30-02 60414300.092702

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PTO/SB/16 (8-00)
Approved for use through 10/31/2002. OMB 0651-0032
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JC997 U.S. PTO 60/414300

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Alexandre A.	Zavadtsev	Moscow, Russia
Gary F.	Bowser	Auburn, Indiana

☐ *Additional inventors are being named on the ___ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

TWO SECTION PARTICLE ACCELERATOR WITH CONTROLLED BEAM CURRENT

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

☒ Customer Number: 006980 (Type Customer Number here)

006980
PATENT TRADEMARK OFFICE

OR

☐ Firm or Individual Name					
Address					
Address					
City		State		ZIP	
Country		Telephone		Fax	

ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 5
☐ CD(s), Number
☒ Drawing(s) *Number of Sheets* 7
☒ Other (Specify): Check No. 299067; Unexecuted Declarations (2)
☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

☒ Applicant claims small entity status. See 37 CFR 1.27
☒ A check or money order is enclosed to cover the filing fees
☐ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number 20-1507
☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT($): 80.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.
☒ No.
☐ Yes, the name of the U.S. Government Agency and the Government contract number are: ____________

Respectfully submitted,

SIGNATURE [signature] Date 09 / 27 / 02

TYPED or PRINTED NAME R. Stevan Coursey

REGISTRATION NO. *(if appropriate)* 39,949

TELEPHONE (404) 885-3632

Docket Number: SCAN3.PRV

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

EXPRESS MAIL LABEL NO. EL812796844US

1053157_1.DOC

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FEE TRANSMITTAL for FY 2002

Patent fees are subject to annual revision

TOTAL AMOUNT OF PAYMENT ($) 80.00

Complete if Known	
Application Number	Unassigned
Filing Date	September 27, 2002
First Named Inventor	Zavadtsev, Alexandre A.
Examiner Name	Unassigned
Group Art Unit	Unassigned
Attorney Docket No.	SCAN3.PRV

METHOD OF PAYMENT

1. ☐ The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number: 20-1507

Deposit Account Name: TROUTMAN SANDERS LLP

☒ Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

☒ Applicant claims small entity status. See 37 CFR 1.27

2. ☒ Payment Enclosed: ☒ Check ☐ Credit card ☐ Money Order ☐ Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	740	201	370	Utility filing fee	
106	330	206	165	Design filing fee	
107	510	207	255	Plant filing fee	
108	740	208	370	Reissue filing fee	
114	160	214	80	Provisional filing fee	80.00
				SUBTOTAL (1)	($) 80.00

2. EXTRA CLAIM FEES

	Extra Claims		Fee from below		Fee Paid
Total Claims		-20** =		X $	= $
Independent Claims		- 3** =		X $	= $
Multiple Dependent					=

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	84	202	42	Independent claims in excess of 3
104	280	204	140	Multiple dependent claim, if not paid
109	84	209	42	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0.00

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet.	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for ex parte reexamination	
112	920*	112	920*	Requesting publication of SIR after Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	400	216	200	Extension for reply within second month	
117	920	218	460	Extension for reply within third month	
118	1440	218	720	Extension for reply within fourth month	
128	1960	228	980	Extension for reply within fifth month	
119	320	219	160	Notice of Appeal	
120	320	220	160	Filing a brief in support of an appeal	
121	280	221	140	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1280	241	640	Petition to revive - unintentional	
142	1,280	242	640	Utility issue fee (or reissue)	
143	460	243	230	Design issue fee	
144	620	244	310	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	180	126	180	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	740	246	370	Filing a submission after final rejection (37 CFR 1.129(a))	
149	740	249	370	For each additional invention to be examined (37 CFR § 1.129(b))	
179	740	279	370	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	
Other fee (specify)					

* Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0.00

SUBMITTED BY

		Complete (if applicable)			
Name (Print/Type)	R. Stevan Coursey	Registration. No. (Attorney/Agent)	39,949	Telephone	404-885-3632
Signature				Date	September 27, 2002

WARNING: Information on this may become public. Credit card Information should not be included on this form. Provide credit card information and authorization on PTO-2038.

1053154_1.DOC

PATENTS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Provisional Patent Application of: **ZAVADTSEV, Alexandre A. and BOWSER, Gary F.**	Group Art No.: **Unassigned**
Serial No.: **Unassigned**	Examiner: **Unassigned**
Filed: **September 27, 2002**	Atty. Ref.: **SCAN3.PRV**
For: **TWO SECTION PARTICLE ACCELERATOR WITH CONTROLLED BEAM CURRENT**	

"Express Mail" Mailing Label Number: EL812796844US
Date of Deposit: September 27, 2002
I hereby certify that this correspondence and the papers described herein are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above to the Commissioner for Patents, Box Provisional Patent Application, Washington, D.C. 20231.

R. STEVAN COURSEY
Reg. No. 39,949

Signature

TRANSMITTAL LETTER

September 27, 2002

Commissioner for Patents
Box Provisional Patent Application
Washington, D.C. 20231

Sir:

In connection with the above-identified United States Provisional Patent Application which is being filed herewith under 35 U.S.C. § 111(b), enclosed please find the following documents for filing:

1. Provisional Application for Patent Cover Sheet;
2. Unexecuted Declarations and Powers of Attorney for Alexandre A. Zavadtsev and Gary F. Bowser;
3. United States Provisional Patent Application of Alexandre A. Zavadtsev and Gary F. Bowser, including: 5 pages of specification, 2 claims, and 7 sheets of drawings;
4. Check No. 299067 in the amount of $80.00 in payment of the Provisional Patent Application Filing Fee;
5. Fee Transmittal for FY 2002; and,
6. Return Postcard.

Respectfully submitted,

TROUTMAN SANDERS LLP

By: _____
R. Stevan Coursey
Reg. No. 39,949
Attorney for Applicant

TROUTMAN SANDERS LLP
600 Peachtree St., NE
Bank of America Plaza, Suite 5200
Atlanta, Georgia 30308-2216
(404) 885-3632

TWO SECTION PARTICLE ACCELERATOR WITH CONTROLLED BEAM CURRENT

FIELD OF THE INVENTION

Invention belongs to the area of accelerator technology, specifically, to the technology of high-frequency electron accelerators with controlled beam current and could be used, for example, in the development of medical instrument and material as well as food sterilizing, dangerous substance neutralization systems, etc.

BACKGROUND OF THE INVENTION

Various accelerating system RF power supply circuits are used in charged particle accelerators. For example, single-section electron accelerator [1] contains magnetron, which serves as RF power generator, one accelerating section that is a cavity made in a form of a series of coupled accelerating cells and coupling cells, and ferrite isolator for magnetron and accelerating section RF isolation. Ferrite circulator may be used instead of ferrite isolator. However, use of ferrite isolation devices results in RF generator power losses in ferrite and high accelerator cost. Technical solutions of accelerators with three accelerating sections [2] and two combined sections [3] are known. In the said accelerators a 3-dB waveguide hybrid junction is used as isolator. The 3-dB waveguide hybrid junction contains two parallel waveguides with a common wide wall having a coupling window. However, high electrical field at the edges of the coupling window limits maximal power of the said 3-dB waveguide hybrid junction.

Of the known linear charged particle accelerators, the closest by technical essence to the one proposed here is a two-section linear electron accelerator [2] that has been selected as prototype (see Fig. 1) and in which two-section accelerating system is powered from magnetron 1 via 3-dB waveguide hybrid junction 6. Each of accelerating sections 2 and 3 is a cavity that is made in the form of biperiodic structure with alternating coupled accelerating and coupling cells. Magnetron 1 generates RF power, which is a wave of electromagnetic field. This wave is transmitted from generator to the accelerating system via a waveguide, that is a rectangular hollow pipe. The said wave generates electromagnetic field in the accelerating system. Injected by injector 4 electrons are accelerated in the said field. 3-dB waveguide hybrid junction 6 serves for magnetron 1 isolation from accelerating systems 2 and 3, that is this junction has to let RF

power from magnetron 1 go to accelerating systems 2 and 3, and prevent the reflected from accelerating systems 2 and 3 wave from returning to magnetron 1, instead directing it to the waveguide load 5. In this case, the 3-db waveguide hybrid junction 6 represents two rectangular waveguides having a common wide waveguide side 7 and a coupling window 8.

However, the said accelerator has several disadvantages.

First of all, 3-dB waveguide hybrid junction with coupling window in a common wide wall between waveguides is used in the said accelerator similarly as in accelerators [2] and [3]. Therefore maximal power of the 3-dB waveguide hybrid junction is limited by high electric field at the edges of the coupling window.

For the second, the 3-dB waveguide hybrid junction configuration of the said accelerator, like that in three-section accelerator [3], is such that each of the waveguides have double turns to provide for coupling with accelerating sections. This results in big accelerator overall dimensions.

For the third, in the known accelerators [1, 2, and 3] coupling coefficient of waveguide with accelerating section is constant and cannot be changed. Reflection in the feeding waveguide coefficient dependence on the electron beam current I is shown in Fig. 2. As is seen in Fig. 2, for a given accelerator, there is only one single electron beam current I value that equals I_0, at which there is no RF power reflection in the feeding waveguide (S11 = 0), that is which corresponds to the most efficient accelerating mode.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The proposed energy efficient linear charged particle accelerator with controlled beam current is shown in Fig. 3a, 3b, and 3c.

Linear accelerator consists of RF generator 1, two accelerating sections 2 and 3, injector 4, waveguide load 5, and 3-dB waveguide hybrid junction 6. 3-dB waveguide hybrid junction 6 represents two parallel waveguides having a common narrow wall 7, in which a waveguide coupling window 8 and a drift tube 9 for particles to pass are made. Input waveguide 10 of the 3-dB waveguide hybrid junction 6 is connected to the RF generator 1, the fourth waveguide 11 is connected to the waveguide load 5, the first output waveguide 12 is connected to the first accelerating section 2 via coupling hole 14, the second output waveguide 13 is connected to the second accelerating section 3 via coupling hole 15. Movable shorting devices 16 and 17 are

placed in output waveguides 12 and 13 such that the axis of accelerating sections is located between the coupling window of waveguides and the shorting devices.

The proposed linear accelerator operates as follows. Power from RF generator 1 in the form of electromagnetic field wave is fed into the 3-dB waveguide hybrid junction 6 input waveguide 10, then it is divided by half in the 3-dB waveguide hybrid junction 6 and through 3-dB waveguide hybrid junction 6 output waveguides 12 and 13 and coupling holes 14 and 15 is directed to the accelerating sections 2 and 3. Exiting from injector 4 electrons are accelerated in accelerating sections 2 and 3 by electric field that is created by RF generator 1 power. RF power reflected from accelerating sections 2 and 3 during the transient process of filling sections 2 and 3 with the electromagnetic field energy passes through 3-dB waveguide hybrid junction 6 and is absorbed by waveguide load 5, and does not return to RF generator 1. By moving movable shorting devices 16 and 17 that are placed in 3-dB waveguide hybrid junction 6 output waveguides 12 and 13 coupling coefficients of waveguides 12 and 13 with accelerating sections 2 and 3 are changed. For each beam current value there is only one value of coupling coefficient of waveguides 12 and 13 with accelerating sections 2 and 3, at which all power from waveguides 12 and 13 is delivered to accelerating sections 2 and 3 without reflections and is maximally utilized for charged particle acceleration. Moving shorting devices 16 and 17 in waveguides 12 and 13 allows optimal setting of coupling with accelerating sections 2 and 3 at any beam current value and thus providing for efficient RF generator 1 power utilization without reflections in waveguides 12 and 13. In waveguide segments 12 and 13, between the cross-section of the said segments that passes through the axis of accelerating sections 2 and 3 and the cross section of shorting devices 16 and 17 a standing wave is created such that the longitudinal component of electric field E_z in waveguide 12 and 13 cross-section that passes through the axis of accelerating sections 2 and 3 ($z = 0$) depends on the longitudinal position z_0 of shorting devices 16 and 17 in the following manner (see Fig. 4):

$$E_z = E_0 \sin(k(z_0 - z)).$$

For each beam current value there is only one value of coupling coefficient of waveguides 12 and 13 with accelerating sections 2 and 3, at which all power from waveguides 12 and 13 is delivered to accelerating sections 2 and 3 without reflections and is maximally utilized for charged particle acceleration. Moving movable shorting devices 16 and 17 in waveguides 12 and 13 allows setting optimal coupling coefficients with accelerating sections 2 and 3 at any beam

current value thus providing for efficient RF generator 1 power utilization without its reflections in waveguides 12 and 13. The movable shorting devices 16 and 17 could be made in the form of movable plungers with choke grooves or in the form of series of rods welded into waveguide in the plane of the required shorting. In the latter case coupling regulation is done by placing replaceable waveguide segments with rods that are placed at various rod locations.

Electric field in a rectangular waveguide equals zero on the narrow waveguide wall. Therefore, the employed 3-dB waveguide hybrid junction 6 electrical field is maximal and corresponds to maximal power of a regular waveguide.

The proposed engineering solution has the following advantages as compared to the prototype.

Firstly, maximal power in 3-dB waveguide hybrid junction with coupling window on the common narrow wall is significantly higher than that of a prototype.

Secondly, the possibility of setting optimal coupling with accelerating sections allows for more efficient utilization of RF generator power for each beam current value.

Thirdly, the proposed engineering solution is much more compact than prototype, which allows for reduction of accelerator overall dimensions and cost.

10 MeV electron accelerator, in which 6 MW pulse power and 2856 MHz operating frequency klystron is used as RF generator could be considered as an example of specific implementation of energy efficient linear charged particle accelerator. Beam pulse current can be changed within the range of 0.1 A to 0.7 A. Coupling coefficient of waveguides with accelerating sections can be changed within the range of 1.5 to 5.0 by moving movable shorting devices.

CLAIMS

What is claimed is:

1. An apparatus as described herein and as shown in the Figures, including each and every limitation and embodiment.

2. A method of operation as described herein and as shown in the Figures, including each and every limitation and embodiment.

DECLARATION AND POWER OF ATTORNEY

In Re Application: Alexandre A. Zavadtsev and Gary F. Bowser Attorney's Docket No.: SCAN3.PRV

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name. I believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled, **TWO SECTION PARTICLE ACCELERATOR WITH CONTROLLED BEAM CURRENT**, the specification of which:

- ☒ is attached hereto.
- ☐ was filed on ____ as Application No.____
- ☐ was amended on ___.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I do not know and do not believe that the same was ever known or used by others in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to the date of this application. I further state that the invention was not in public use or on sale in the United States of America more than one year prior to the date of this application. *I understand that I have a duty of candor and good faith toward the Patent and Trademark Office,* and I acknowledge the duty to disclose information which is material to the patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(d) of the foreign application(s) for patent or inventor's certificate listed below, and have also identified below any foreign application for patent or inventor's certificate disclosing subject matter in common with the above-identified specification and having a filing date before that of the application on which priority is claimed:

Application No.	Country	Filing Date	Priority Claimed Under 35 USC §119
_____	_____	_____	☐ Yes ☐ No

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

Application Serial No.	Filing Date
_____	_____

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter disclosed and claimed in the present application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status of United States Application:
_____	_____	☐ Patented, ☐ Pending, ☐ Abandoned

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statement were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patents issuing thereon.

POWER OF ATTORNEY. I hereby appoint Troutman Sanders LLP, having a Customer Number of 006980, and the attorneys and agents that are associated with this Customer Number from time to time, to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Send correspondence to: **TROUTMAN SANDERS, LLP**
Attention: Patent Docketing Clerk - 46th
600 Peachtree Street, N.E., Suite 5200
Atlanta, Georgia 30308-2216

Direct telephone calls at **(404) 885-3632** to:
R. Stevan Coursey, Reg. No.: 39,949

	First	Middle/MI	Last	
Full name of joint inventors:	Alexandre	A.	Zavadtsev	Citizenship: Russia
Inventor's signature				Date:
Residence and Post Office Address: 4-161 Kotovskogo Str., Reutov, Moscow Region, 143952 Russia				

60412300 .092702

DECLARATION AND POWER OF ATTORNEY

In Re Application: Alexandre A. Zavadtsev and Gary F. Bowser Attorney's Docket No.: SCAN3.PRV

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name. I believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled, **TWO SECTION PARTICLE ACCELERATOR WITH CONTROLLED BEAM CURRENT**, the specification of which:

- ☒ is attached hereto.
- ☐ was filed on ____ as Application No.____
- ☐ was amended on ___.

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I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(d) of the foreign application(s) for patent or inventor's certificate listed below, and have also identified below any foreign application for patent or inventor's certificate disclosing subject matter in common with the above-identified specification and having a filing date before that of the application on which priority is claimed:

Application No.	Country	Filing Date	Priority Claimed Under 35 USC §119
____________	______	_________	☐ Yes ☐ No

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

Application Serial No.	Filing Date
________________	________

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter disclosed and claimed in the present application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status of United States Application:
________________	________	☐ Patented, ☐ Pending, ☐ Abandoned

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statement were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patents issuing thereon.

POWER OF ATTORNEY. I hereby appoint Troutman Sanders LLP, having a Customer Number of 006980, and the attorneys and agents that are associated with this Customer Number from time to time, to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Send correspondence to: **TROUTMAN SANDERS, LLP**
Attention: Patent Docketing Clerk - 46th
600 Peachtree Street, N.E., Suite 5200
Atlanta, Georgia 30308-2216

Direct telephone calls at **(404) 885-3632** to:
R. Stevan Coursey, Reg. No.: 39,949

	First	Middle/MI	Last	
Full name of joint inventors:	Gary	F.	Bowser	Citizenship: United States
Inventor's signature				Date:
Residence and Post Office Address: 2702 CR 68, Auburn, Indiana 46706				

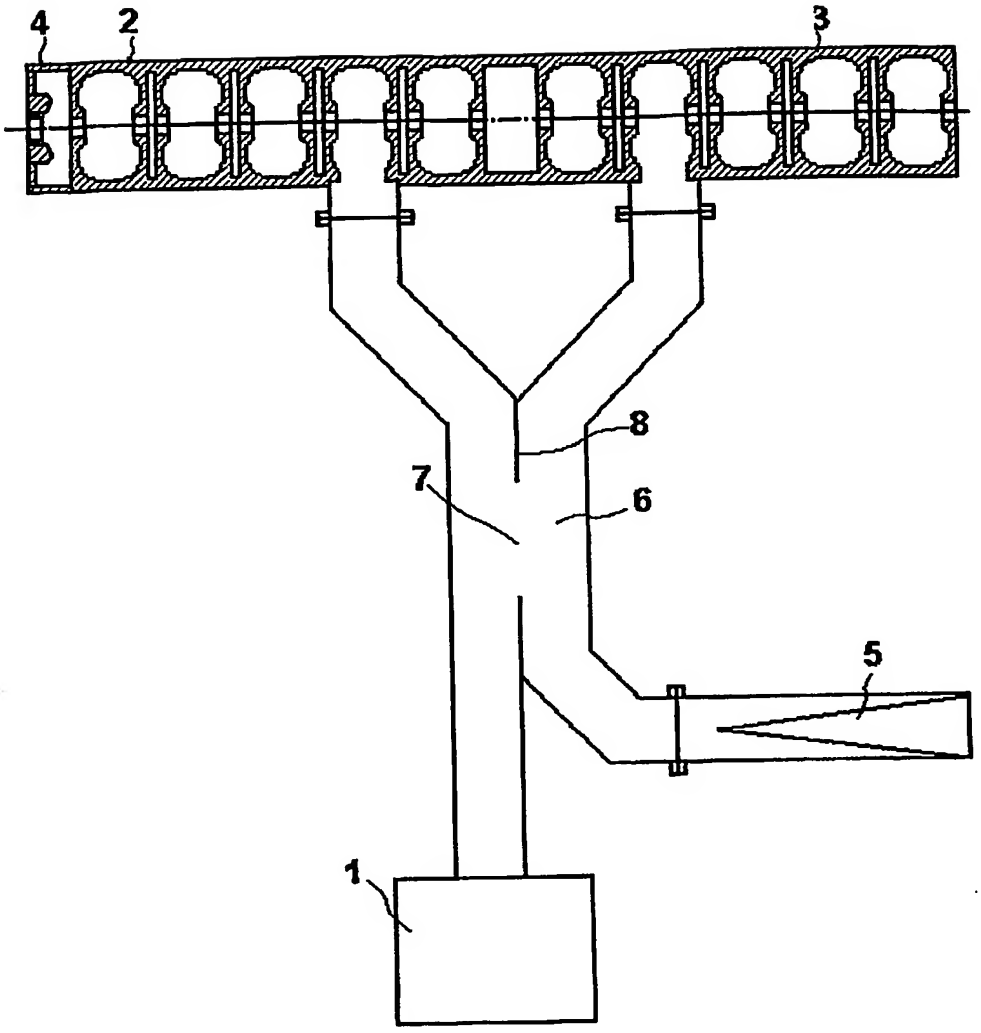


Fig.1.

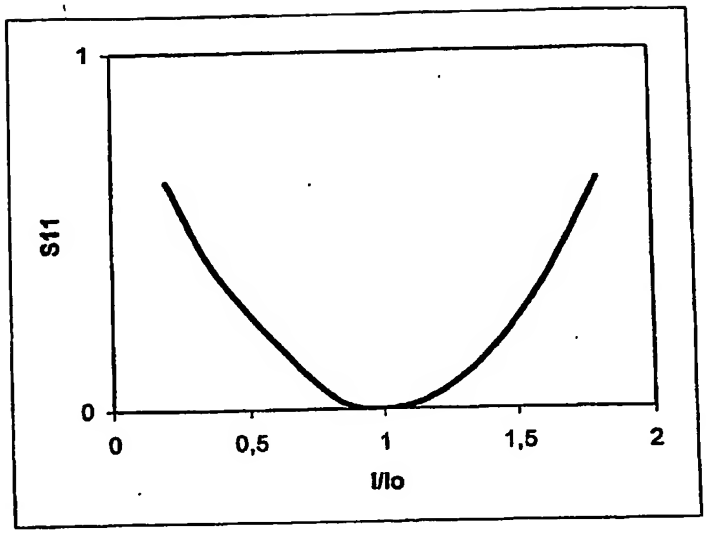


Fig.2.

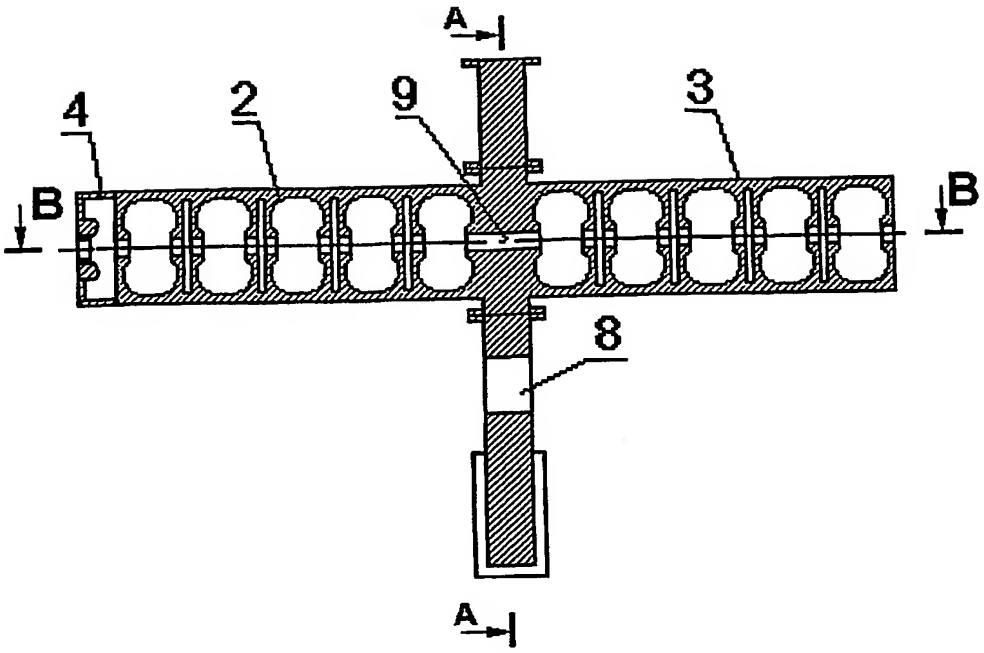


Fig.3a.

A-A

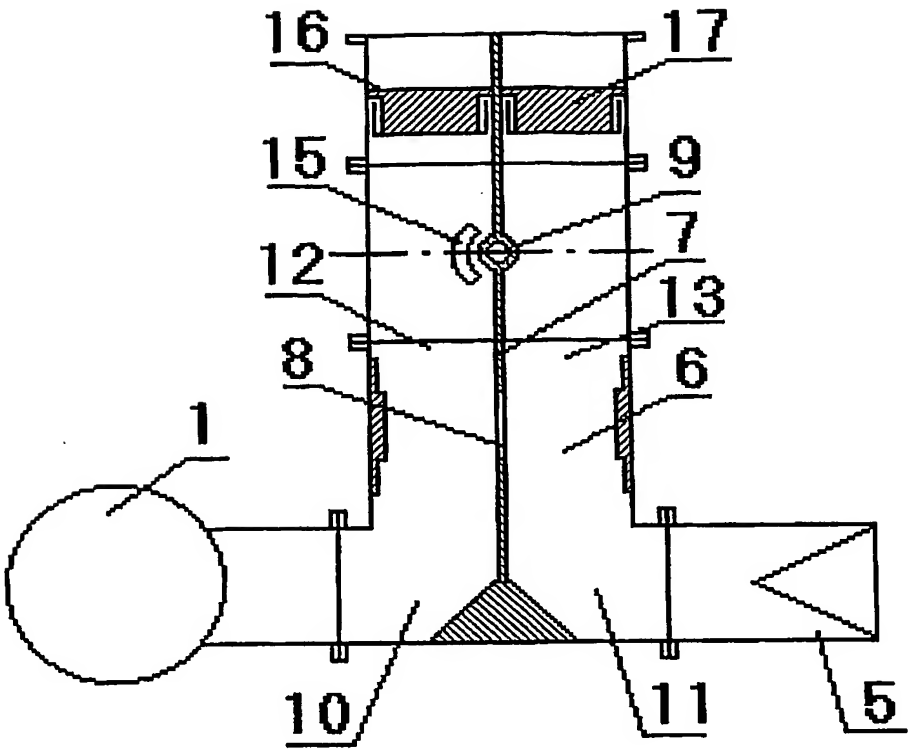
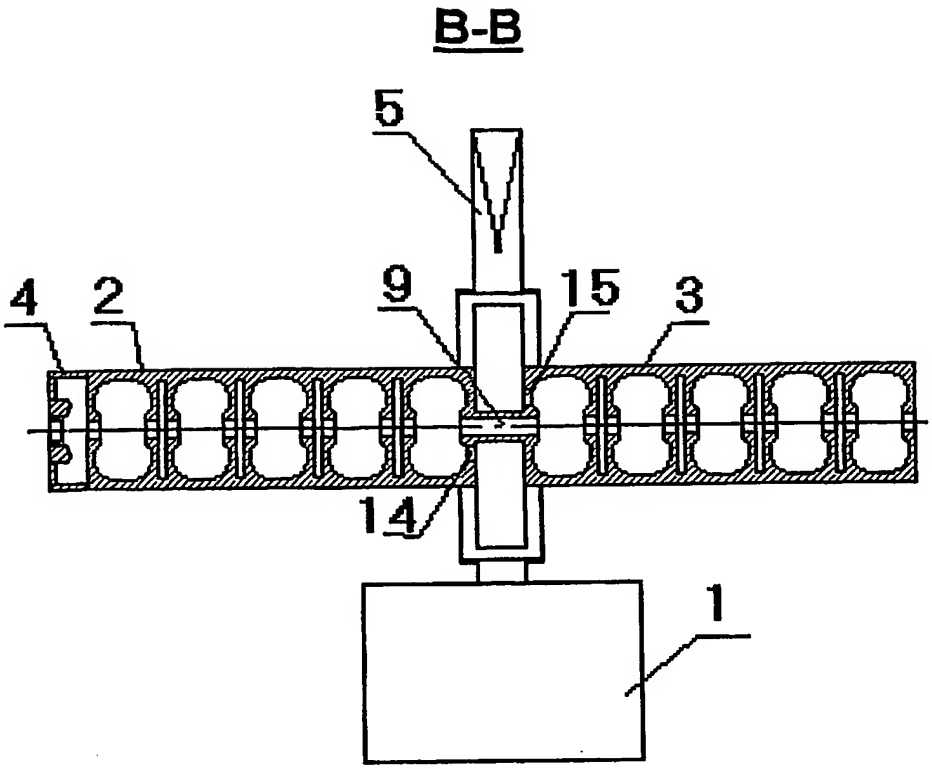


Fig.3b.



Fif.3c.

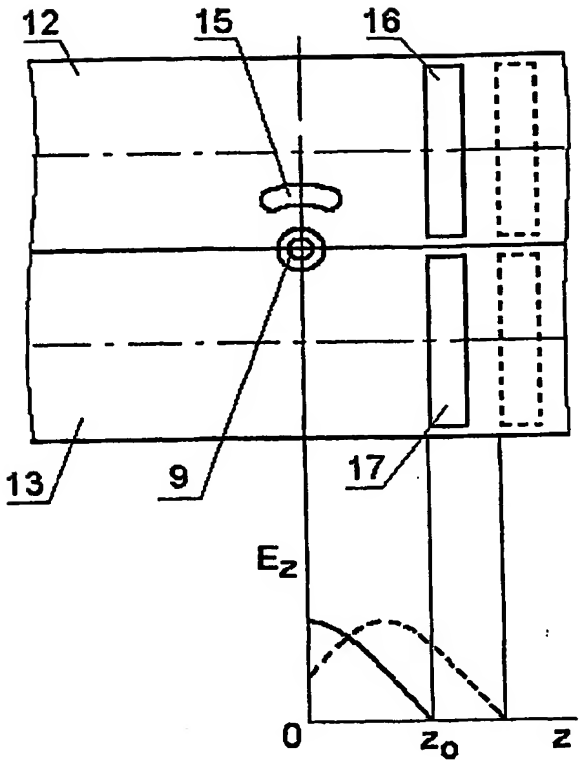


Fig.4.

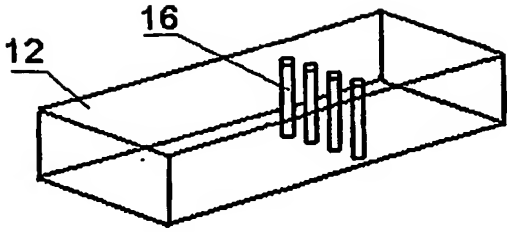


Fig.5.